PATENT SPECIFICATION

DRAWINGS ATTACHED

830,283

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COMPLETE SPECIFICATION

Rolling Lobe Type Air Spring and Method of Manufacture

We, THE GOODYEAR TIRE & RUBBER COMPANY, a corporation organized under the Laws of the State of Ohio, United States of America, with offices at 1144 East Market Street, Akron, Ohio, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to air springs of the rolling-lobe type, as distinguished from the regular lobe type of spring which is of generally accordian shape at its outer surface or corrugated to produce a series of rounded lobes which, in the compression and expansion of the spring, tend to increase and decrease in diameter, thereby changing the effective area within the spring upon which the load acts.

One object of this invention is to provide an air spring which has a controlled outer diameter established by the construction of the spring itself and does not rely upon separate external means for controlling that diameter. Specifically, the invention resides in providing a spring of this character which is manufactured with cords arranged at predetermined angles with reference to an element of a generally cylindrical surface.

More specifically, by designing an air spring in which the outer diameter thereof will remain constant during operation, any lateral support for the outer surface of the spring is eliminated and friction is reduced by eliminating this outer support. Also the danger of abrasion of the fabric of the spring is reduced, because foreign matter accumulating on the outside of the fabric does not come between the fabric and a lateral support which is sometimes provided in springs of this character. With a spring of the character to be described, substantially the only resistance to its operation is the amount of internal friction which may develop within the material of the spring itself, and this is relatively small.

Another object of this invention is to improve the normal ride of an automobile or the like so that, in the normal range of deflections for relatively smooth roads, the spring will be relatively soft, the softness to be determined by design of the spring.

A specific object of this invention is to control the spring rate so that during normal driving the spring will be relatively soft to give easy riding, and during the movement of the spring to extreme positions the pressure within the spring may be controlled to any degree desired by a car manufacturer without changing the construction of the flexible wall of the spring. Particularly, this invention relates to controlling the normal driving range, the jounce and the rebound by the shape of a piston with which the flexible wall of the spring is associated.

The effective cross section of the spring can be controlled by using the same flexible chamber and a properly shaped piston operating at one or both ends of the air spring.

Another object of this invention is to provide an air spring with a free floating bead reinforcement at each end, that is a bead which is free of the fabric and rubber surrounding the same, so that the fabric and the rubber can rotate around the spring when the spring is mounted in position, and without putting undue stress in the rubber or fabric. Once mounted and under load this bead and associated rubber and fabric parts adjacent it remain substantially in fixed relation with respect to each other, so that there is little if any friction developed between the two in the normal operation of the spring. This is because of the fact that the ends of the spring are so mounted that the beaded edges thereof remain constantly in the same position under normal riding conditions, although this does not mean that under extreme conditions there will not be some rotation. In order to further assure that there will be no wear occurring between the solid bead and the surrounding rubber and fabric, it is within the scope of this invention to provide a lubricant therebetween which can be applied

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at the time of manufacture.

In the drawings:

Fig. 1 is a partial cross-sectional view illustrating the construction of the spring in the first step of manufacture;

Fig. 2 is a cross-sectional view of the molding apparatus and shows the step of molding the spring to final contour;

Fig. 3 is a cross-sectional view through one form of the spring in loaded condition;

Figs. 4, 5, 6, 7 and 8 are views similar to Fig. 3 showing modifications of the cylinder illustrated in Fig. 3; and

Fig. 9 shows a further modification.

Essentially, the air spring comprises a tube with a flexible side wall made of a plurality of layers of cord fabric formed with beads at the opposite ends thereof to provide mounting means for mounting the ends on rigid end plates to form an air receiving chamber. The angle of the cords as hereinafter used is the angle between the direction of the cords and an element 2 of the surface. This term "element" means an imaginary line extending longitudinally of the said side wall and which would be formed by a plane through the axis of the wall and intersecting the surface thereof. The cords in the side wall are arranged at an angle substantially less than 54° when the wall is not under load as in Fig. 2, but at an angle which, when a load is imparted to the inflated spring, will be altered to the extent that it will be at what is referred to herein as the "loaded angle of equilibrium".

The unloaded or normal angle of equilibrium is well understood in the art as being of an angle of approximately 54° 44′. It is the maximum angle beyond which a cord will not move when a tubular article is subjected only to internal pressure with the ends unrestrained. In hose, where it is desired that the hose be made inexpansible, such as in hydraulic hose used on hydraulic brake systems, the cords are built into the hose at an angle of 54° 44′, for the purpose of limiting the expansion of the hose, so that pressure on the brake will not expand the hose and so ensure proper brake pressure. The same principle applies to the cords in the wall of an air spring such as described. However when the spring is inflated and is also under axial load, the angles of the cords are what has been defined as "the loaded angle of equilibrium".

In the present instance, this angle is used as the maximum angle defining the extent to which the cylindrical body of the spring may expand to maintain its outer surface substantially cylindrical throughout the major portion of its length when pressure is introduced into the cylinder and the spring is loaded. Thus, if the outer diameter of the spring is calculated for the load to be carried, it is possible to design the spring by providing an initial cord angle which, when the spring is inflated and under load, will cause the cord angle to increase to at least approximately the loaded angle of equilibrium under normal operating conditions for the spring, but will permit the cords near the ends to remain at smaller angles. By thus maintaining the outer diameter fixed during operation of the spring in all positions, the effective cross sectional area upon which the air pressure acts will remain constant if desired, or it may be controlled in any desired manner by the piston which will be described hereinafter.

Previous to this invention, known devices have employed restraining elements exteriorly of the flexible side wall to prevent expansion beyond a certain diameter. Such means have generally comprised cylindrical rigid walls embracing the flexible side wall. The present invention avoids the use of such a separate element and yet is able to obtain the necessary control of the outside diameter without the use of additional restraining elements.

For the sake of the description and not to be considered as limiting as far as the invention is concerned, the invention shown in Figs. 1, 2 and 3 will be described as applied to an air spring in which the maximum diameter under load is 7″. In order to produce a spring having such characteristics, a tubular member such as shown in Fig. 1 is constructed of cord fabric and as illustrated comprises two layers 1 and 1a which have cords extending at opposite angles to the element 2 of the surface.

The two layers of cord 1 and 1a may be built on a cylindrical drum and the edges of the layers wrapped about inextensible beads 3 as illustrated at 4, similar to the manner in which beads are tied into the cords of an automobile tire in building the carcass therefor. For a 7″ maximum outer diameter as shown in Fig. 3, the fabric originally is wrapped about a drum of 3⅜″ diameter with the cords arranged at an angle of 30°. This flexible wall is then placed in a mold 5 having a cover 6, with the beads 3 at the upper and lower ends of the side wall centered about the bosses 7 and 8 respectively at the top and bottom of the mold. These bosses are bevelled as at 9 and 10, so as to produce sloping seats on the beaded edges of the side wall, the angle of bevel being preferably in the order of 5 to 15° and sloping in a general direction inwardly and axially of the side wall as shown. An expansible air bag 11 having an inflation valve 12 of any description is placed within the side wall and air is introduced into the air bag under sufficient pressure to expand the side wall until it engages the walls of the mold. This removes the slack from the cords and insures that each cord will take its fair share of the load in the ultimate structure. The inner wall of the mold for a 7″ spring should be about 4½″ inside diameter. After vulcanization the side wall will have the shape shown in Fig. 2. During this expansion it will be noted that, since the beads 3 at the upper end of the tubular member are inextensible, the molded

beaded edges do not expand and instead of being at the outside of the side wall as in Fig. 1 they are now on the inside of the side wall as illustrated in Fig. 2. Also, during this expansion of the tubular side wall the cords change their angle to approximately 37° and this is the unloaded angle for the cords in the sleeve.

The spring structure when under load is shown best in Fig. 3. There the tubular side wall is shown mounted between end plates 13 and 14. The upper plate 13 has a cylindrical boss 15 provided with a bevelled edge forming a seat on which the upper bead 3 of the spring is seated. The lower plate 14 is provided with a cylinder 16 mounted thereon, either permanently or detachably, and the upper end of this cylinder is provided with a boss 17 having a bevelled seat for mounting the lower beads 3 of the side wall. The bosses 15 and 17 are each provided with an enlarged flange 18 which is just slightly larger than the adjacent boss to provide a retaining shoulder which will engage the mounted beads to prevent their accidental dislodgment upon an extension of the spring beyond normal operating ranges. The retaining force of these flanges does not interfere with the mounting and dismounting of the beads on the bosses, and in some instances these flanges may be found to be unnecessary. The fit of the beads 3 on their respective bosses is such that the surfaces of the beads will be somewhat compressed to effect a good air seal between end walls formed by the bosses 15 and 17 and the beads of the side wall to thus provide an closed air chamber comprising the side wall and end walls.

In the form of the invention illustrated, the inflating means for the spring is not shown, but such means is normally well understood in the art and normally comprises a suitable valve communicating with a passage leading through one of the end walls. Such inflation means is also connected with and forms a part of the fluid system which controls the action of the spring.

Normally, such springs are operated entirely with air under pressure as the fluid medium, but it is within the scope of this invention to employ a fluid system in which the fluid is a liquid in part and air or a compressible gas in part. For example, the fluid could entirely fill the spring and lead through a passage in one of the end walls to an air chamber which would permit the controlled loading of the spring. However, in the preferred form of the invention the spring will employ only air or gas under pressure and it may be connected or not to a separate reserve air chamber. Usually, such reserve air chambers are provided to give the extra volume required, so that the spring will give a softer ride. In other words, instead of constructing a larger air chamber of flexible material and end walls as shown in Fig. 3, a smaller chamber may be used and an auxiliary chamber connected thereto. Such a combination between an air spring itself and reserve air chamber is well understood in the art and forms no part of the present invention.

It will be noted in Fig. 3 which illustrates a loaded condition for the spring, the tubular member is expanded to its maximum diameter which is 7″ in the illustrated embodiment. Except adjacent the ends where the air pressure in the spring and the beads restrict portions of the side wall in a manner to be described presently, the cords lie at the loaded angle of equilibrium or substantially so. In the example given where the cords are initially at 30° the loaded angle of equilibrium will be about 64°. The loaded diameter of the spring is determined by the initial angle of the cords and the initial diameter of the cylinder illustrated in Fig. 1, but regardless of the initial angle used there will always be a definite loaded angle of equilibrium which prevents further diametrical expansion of the spring when this angle of equilibrium has been reached. This is all accomplished without the use of auxiliary restraining members separate from the spring itself as referred to previously with reference to prior known devices.

Further reference to Fig. 3 shows that the lower end of the tubular wall extends from the lower cylindrical portion inwardly in an arc to a position adjacent the cylinder 16 and then follows the contour of the cylinder. The cords in this portion of the wall of course have an intermediate angle and the air pressure within the side wall holds the lower end of the side wall in the shape illustrated in Fig. 3 at all times during the operation of the spring. This condition is not easily explained, except to the extent that the natural tendency of the tubular sleeve is to remain at its molded diameter which is that of the cylinder 16 or approximately so and, therefore, as the load compresses the spring the portions of the cords in the looped areas progressively change their angles to restrict the diameter so that it tends to hug the cylinder 16 during all the positions of the spring.

The effective cross sectional area upon which the air pressure works is represented by a circle area having a diameter equal to the distance between the points 19 and 20. These represent the centers of the arcs formed by the looped ends of the side wall. The effective area is not the entire cross sectional area of the spring. One way to explain this is to point out that if one were to separately consider the part of the loop radially outward of the point 19 and the part radially inward of point 19, it will be found that a portion of the pressure acting on the first part is actually being taken up in axial tension exerted on the outer cylindrical wall of the diaphragm and, therefore, produces no pressure tending to expand the spring in an axial direction. As to the second part, the pressure acts in a downward direction and this also places tension in the smaller diameter of the spring

which in turn tends to pull downward and to expand the spring. Of course, the pressure acts directly on the area just above the piston 16, so that the total pressure is the load determined by an area determined by the distance between points 19 and 20 multiplied by the unit pressure in the spring. Whatever the explanation, it is a well known fact that the effective area is as above determined.

If the points 19 and 20 remain spaced apart the same amount during the full operation of the spring throughout its operating range, then the action of the spring is such that the amount of pressure required to deflect the spring different amounts is directly proportional to the amount of deflection. For example, if the load required to compress the spring 1" is 500 lbs, then each additional inch of compression will require an additional 500 lbs. This can be referred to as a uniform spring rate, and the spring shown in Fig. 3 is designed for such a rate.

Generally speaking, however, this uniform spring rate is not desirable. The cross sectional area of the spring should be such that during the normal operating of the spring on relatively smooth roads, the spring will give a relatively soft ride. That is, the spring should permit the wheels of the vehicle to vibrate readily without imparting this movement to the body of the car. However, in the event an obstacle is encountered on the road or the car is driven over a rough road, it may be desirable to change the softness of the spring in order to cope with the changed riding condition. Without changing the air pressure in the spring the spring rate may be changed by decreasing or increasing the effective cross sectional area upon which the pressure acts. Thus, if the points 19 and 20 are moved closer together, the effective area becomes less and the spring becomes softer because the total resisting force is less and the obstacle that is struck can deflect the spring without giving too much of a jar to the body of the car. Conversely, if in order to prevent bottoming of the spring it is desired to introduce a greater resistance when an obstacle is encountered, the distance between 19 and 20 can be increased so that the total resisting force is increased.

Different automobile manufacturers have different requirements as to the type of action desired in an air spring of this kind, and with the construction herein shown it is possible to deliver to the car manufacturer a spring meeting his requirements merely by employing the same side wall portion and end plates and providing a different shape for the wall of the cylinder 16. By changing the contour of the outer cylindrical wall of cylinder 16, it is possible to secure many variations in the action of the spring shown in Fig. 3. Some of these are illustrated in Figs. 4, 5, 6, 7 and 8.

In each of Figs. 3 to 8 inclusive the positions of the looped ends of the side wall are shown in different positions determined by the loading, these positions being shown in dotted lines. The respective spacing of points 19 and 20 is also shown and dotted lines indicate the loci of the points 19 and 20.

In Fig. 4, the piston 21 corresponding to the piston 16 has a conical outer surface which causes the points 19 and 20 to move outwardly away from each other on increased compression of the spring. Fig. 5 shows a reverse type conical surface on the piston 22 in which the increase of the load on the spring decreases the distance between the points 19 and 20. In Fig. 6, the movement of the points 19 and 20 is such that on either side of the normal loaded position, they move outwardly away from each other so that greater resistance is encountered. This is the result of providing a cylinder which is larger at the ends than at the middle as shown at 23. In Fig. 7, the reverse of Fig. 6 is shown and the pressure becomes less on either side of the normal loaded position, since the outer surface of the piston 24 is larger in diameter at the middle than at the ends thereof. In Fig. 8 an irregular shaped piston 25 is illustrated in which the loci of the points 19 and 20 is an irregular curve so that the effective area changes in a varying degree during the operational movement of the spring.

Fig. 9 illustrates an alternative form of the invention in which instead of providing a single cylinder at one end of the spring two cylinders 26 and 27 are provided on the plates 28 and 29 respectively, these pistons being illustrated as shaped the same as piston 21 in Fig. 4.

The mounting for the tubular sleeve 30 is similar to that shown in the other figures and the action is substantially the same as shown in reference to the other figures, except that part of the looping may occur at one end and part at the other as illustrated. However, practical experience has shown that the looping may at times occur with respect to one piston only or with respect to the other only, and this might not be desirable in some constructions. Furthermore, this form of the invention has the objection that where the rubber portion of the side wall rolls against the piston 26 there is a possibility that accumulated dirt may remain locked within the space between the side wall and the piston 26. This would be undesirable, as it would provide an abrading action on the fabric which would impair the life of the side wall. As far as the lower piston 27 is concerned, its position is similar to those shown in the other forms of the invention and any dirt coming between the sleeve and the piston will have a tendency to work out and fall away from the piston so that the chances of any abrading action are greatly minimized.

Without discussing why these different spring actions are desirable, it will be seen that the area upon which the air pressure works can be controlled by the surface of the cylinder which engages the looped ends of the outer

wall. In other words, the contour of the piston is used to regulate the spring rate for different positions without changing the tubular wall structure itself.

While not deemed to be absolutely necessary, it is preferable to first lubricate the beads 3 before wrapping the fabric about the beads. This is to reduce friction between the beads and the fabric and to prevent the fabric from adhering to the beads. In turning the lower end of the spring inside out as shown in Fig. 3, there is apt to be some twisting movement of the fabric about the beads, and if the beads are lubricated or free of the fabric, the fabric may turn about the beads freely. A suitable lubricant for this purpose is one of the silicon oils or zinc stearate or some such material having known lubricating qualities. However, it is not absolutely necessary to provide such an arrangement. The beads 3 may be and preferably are solid, inextensible metal rings, but they may be inextensible fibers, wires or the like, either formed as single strands or braided. The essential quality is in having the beads made inextensible to firmly hold the beads in sealed relation to the end walls of the chamber. A smooth, solid ring seems to be the most desirable.

In general, in making springs which are designed to have a smaller outer maximum diameter than 7″, the initial angle of the cords shown as 30° in Fig. 1 would be larger. As an example, for a $5\frac{1}{2}$″ spring, the initial cord angle would be 38° and the diameter of the tubular wall will be smaller in comparison, but the ultimate cord angle should approximate that of the loaded angle of equilibrium the same as in the spring shown in Fig. 3, which latter angle, however, may differ somewhat from the loaded angle of equilibrium for a spring of 7″ outer maximum diameter. The walls of the tubular member should not be made so thick that they offer appreciable resistance to the tendency the cords have to change their angles during expansion of the spring, and the walls of course should be sufficiently flexible so that the lower ends will readily form loops as shown in Fig. 3, etc. without placing undue flexing on the cords or generating too much heat. The cords should preferably be of a material which is highly flexible and of high tensile strength as well as low stretch. In fact, it is preferable that substantially all stress be removed from the cords before the cords are embedded in the spring. Nylon is a preferable material for this purpose, but other materials may be used and even fine stranded steel wire either used as single strands or braided or cabled. These, however, require special treatment in order to secure a proper bond to the rubber, whereas the regular fabric or synthetic cords may be more easily bonded to the rubber without special care. As used in the claims "cords" means any such equivalent tension element and "rubbery material" means, natural or synthetic rubber or any material which has like characteristics for forming a pliable air impervious wall for the chamber.

WHAT WE CLAIM IS:—

1. A spring of the class described comprising a tube with a flexible side wall formed of rubbery material and substantially inextensible reinforcing cords, end walls forming with said side wall a chamber for receiving a fluid under pressure, substantially inextensible beads embedded in the side wall adjacent the end walls, the cords each extending from a bead adjacent one end wall to the bead adjacent the other end wall and being anchored to said beads, the cords having angles of substantially less than 54° when the spring is not inflated with some of said cords arranged at opposite angles to those of others of said cords, the rubbery material of the side wall and the angles of the cords permitting expansion of the inflated spring under load until the cords reach substantially the loaded angle of equilibrium, the outer surface of said tube being restrained only by the material of the wall itself.

2. A spring as set forth in claim 1 in which said side wall is substantially cylindrical.

3. A spring as set forth in claim 1 in which said side wall is substantially cylindrical throughout the major portion of its length and has a slightly inturned edge at one of the ends thereof in which the bead at said end is embedded.

4. A spring as set forth in claim 1 in which the opposite ends at the inner surfaces thereof are provided with bevelled seats and the end walls are separate from the side wall and have correspondingly bevelled seats on which said seats on said side wall are mounted to effect an airtight seal between the end walls and side wall.

5. A spring as set forth in claim 4 in which the bevelled seats have an angle in the order of 5° to 15° with the axis of the tubular member.

6. A spring as set forth in claim 1 in which at least one of said end walls is provided with a portion projecting axially outward from the adjacent end of said side wall, said projecting portion having an external surface against which the portion of the side wall adjacent said latter end is adapted to engage when the end walls are moved toward and from each other when the spring is inflated and under load.

7. A device as set forth in claim 6 in which the other end wall of the chamber is similarly provided with a portion projecting axially outward therefrom for engagement with the adjacent end of said side wall as said first projecting portion.

8. A spring as set forth in claim 6 in which said external surface is contoured to different diameters axially thereof.

9. A spring as set forth in claim 8 in which the contour is such that the said external surface decreases in cross section axially outward from said end wall.

10. A spring as set forth in claim 8 in which

the contour is such that the said external surface increases in cross section axially outward from said end wall.

11. A spring as set forth in claim 8 in which the contour is such that the said outer surface first decreases and then increases in cross section axially outward from said end wall.

12. A spring as set forth in claim 8 in which the contour is such that the said outer surface first increases and then decreases in cross section axially outward from said end wall.

13. A spring as set forth in claim 8 in which the contour is such that the said outer surface first increases, then decreases and finally increases in cross section axially outward from said end wall.

14. A spring as set forth in claim 8 in which the contoured surface is cylindrical.

15. A spring as set forth in claim 8 in which the contour of said projecting portion is conical, with the smaller diameter of the conical surface near said bead.

16. A spring as set forth in claim 8 in which the contour of said projecting portion is conical, with the largest diameter of the conical surface near said bead.

17. An air spring comprising a cylindrical flexible outer wall of substantially greater length than diameter and end walls forming a chamber, said cylindrical wall being formed of vulcanised rubber with beads embedded in the ends thereof and cords embedded in said rubber extending from one bead to the other and anchored thereto, one group of said cords extending at a predetermined angle to an element of the surface of said outer wall and another group at an equal but opposite angle to said element, the cords of one group overlying the other group and being bonded thereto, the said angles of said cords being substantially less than 54° in the uninflated spring but the cords in one group having permissible angular movement with reference to the cords of the other group to permit a change of angle of the said cords to substantially that of the loaded angle of equilibrium when there is fluid under pressure in said chamber and the spring is loaded.

18. An air spring as set forth in claim 17 in which the end walls are separate from the cylindrical wall and are releasably connected thereto.

19. An air spring as set forth in claim 18 in which the end walls and cylindrical walls are separate from the cylindrical wall and are releasably sealed with each other under operating conditions by sloping cooperating seats on said end walls and cylindrical wall when moved in a direction toward each other under load to cause wedging engagement therebetween, at least one of said seats being formed of yieldable sealing material to cause airtight sealing engagement of the end walls with said side wall.

20. A method of making an air spring according to claim 1 which comprises the steps of forming a cylindrical wall of at least two layers of rubberized cord fabric arranged on the bias and extending from end to end of the side wall, applying beads to each end of the side walls and anchoring the ends of the cords thereto, expanding the side wall to a greater diameter between said beads while maintaining the cylindrical character of the wall between the beads whereby to increase the angles of the cords to an element of the wall and to tension the cords, and vulcanizing the wall while it is so expanded.

21. An air spring substantially as described with reference to the accompanying drawings.

MARKS & CLERK.

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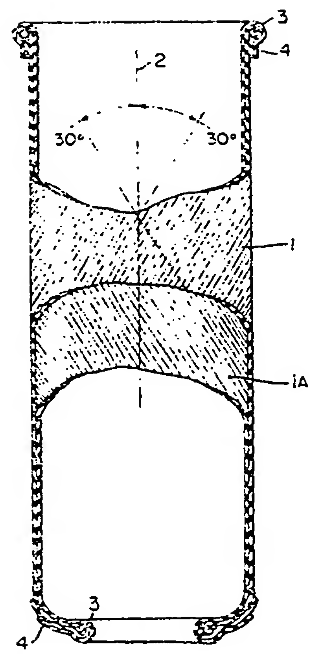


FIG. 1

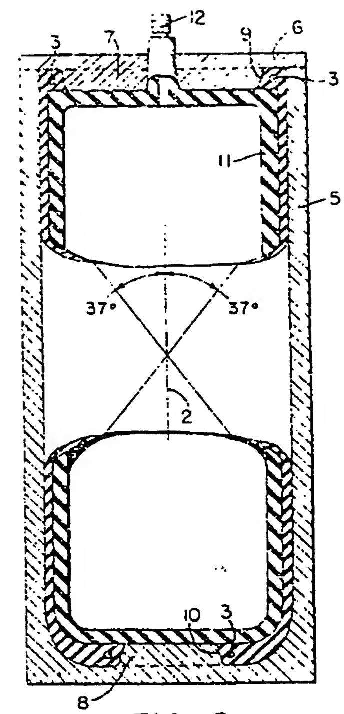


FIG. 2

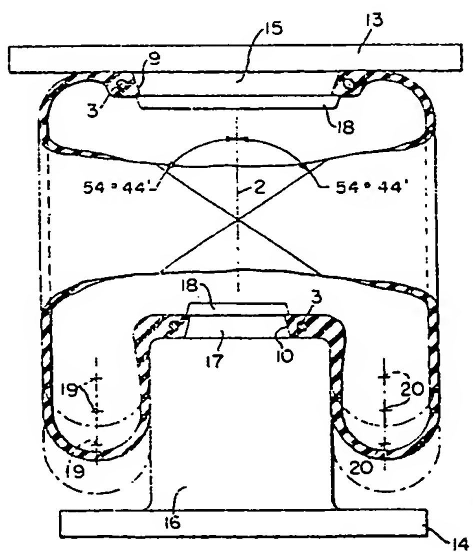
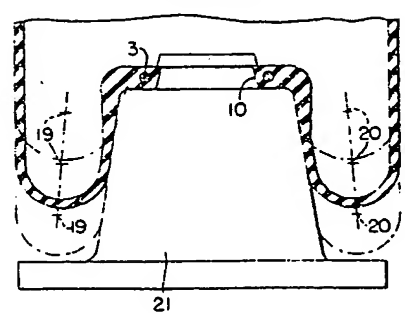


FIG. 3

FIG. 4



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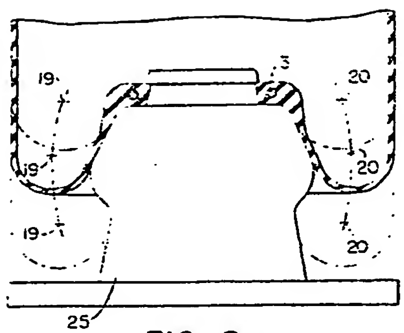


FIG. 8

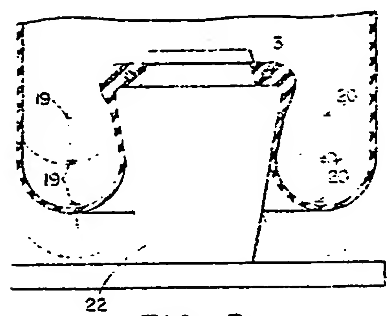


FIG. 5

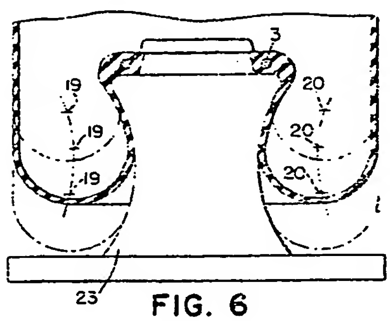


FIG. 6

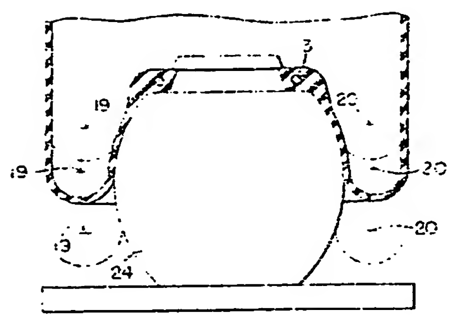
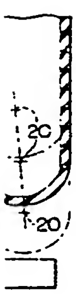


FIG. 7



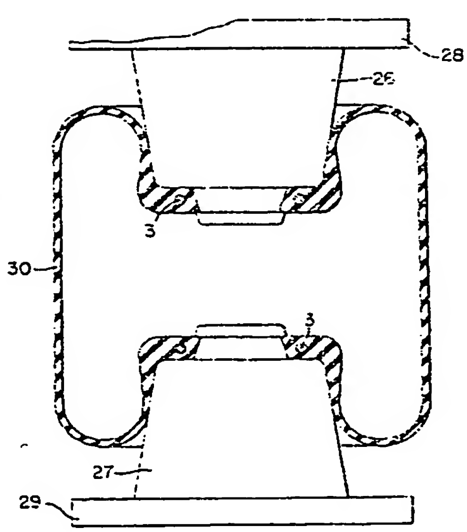


FIG. 9

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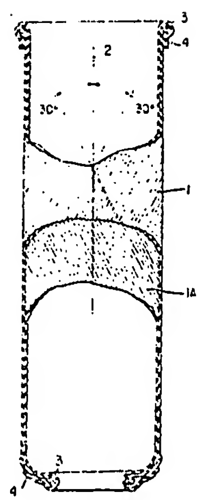


FIG. 1

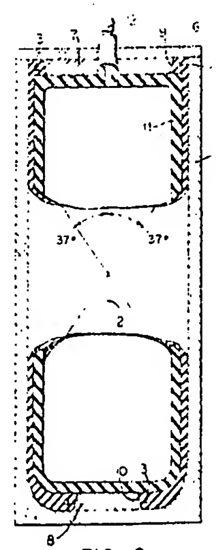


FIG. 2

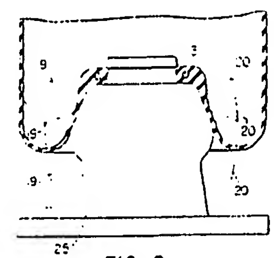


FIG. 8

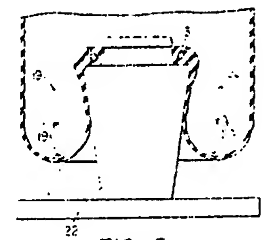


FIG. 5

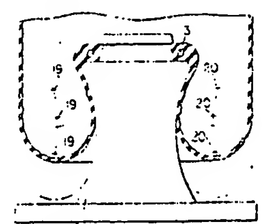


FIG. 6

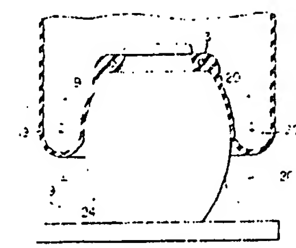


FIG. 7

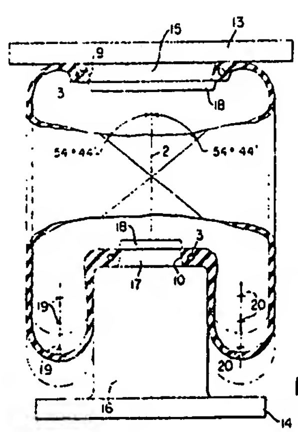
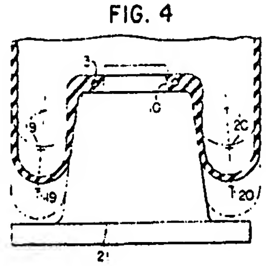


FIG. 3

FIG. 4



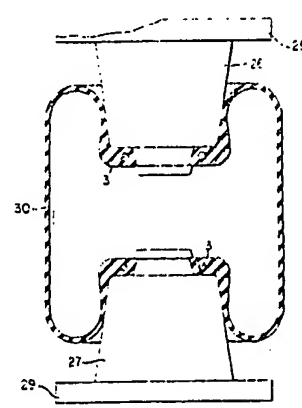


FIG. 9

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